

IEB Fabrication Shop Augmentations



Project Sponsor: TE Connectivity
Special thanks To: Dr. Shu Wang, Dr. Roberto Lu, Dr. Patty Buchanan, & Kory Dean

Project Introduction

Our goal is to develop augmentations for the IEB (Interdisciplinary Engineering Building) assembly lab and machine shop space on the G2 floor to support the functionality by: a **scheduling system**, a **digital twin framework**, and an **AI chatbot**.

Augmentation 1 Scheduling System

Stakeholder analysis Website & App Key Scheduling Attributes

Ideating

- Empathy maps for stakeholders: departments, students, ESOs, staff

Prototyping

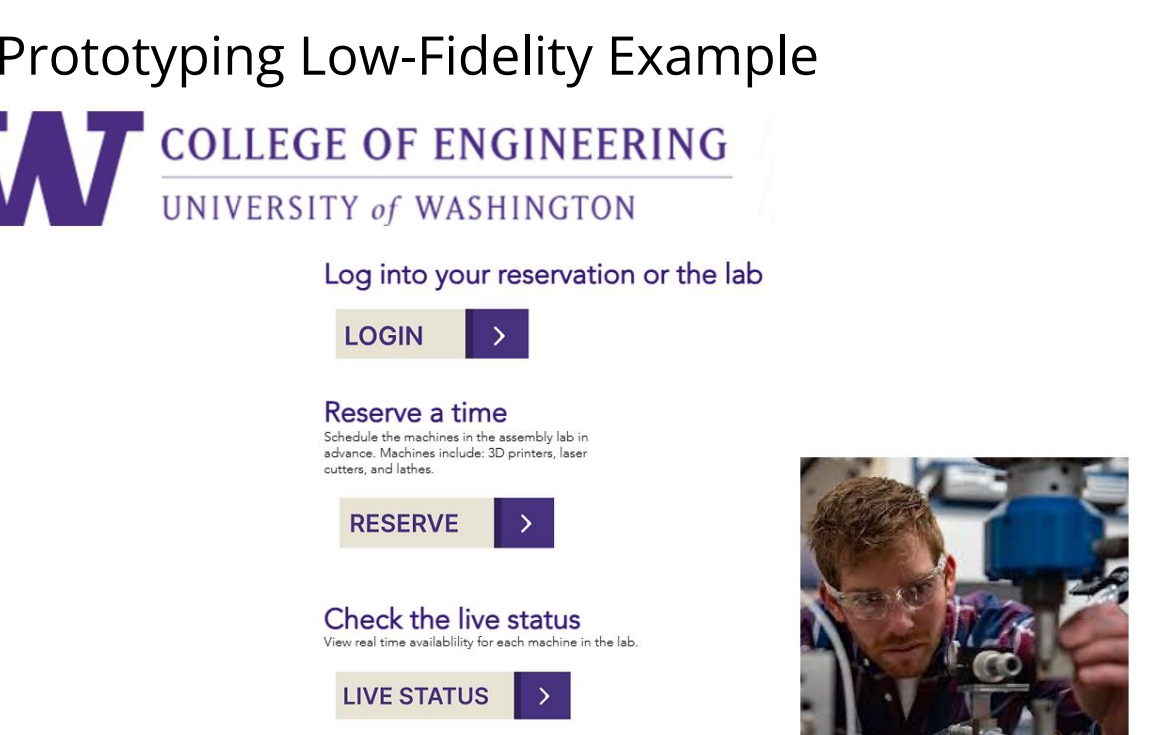
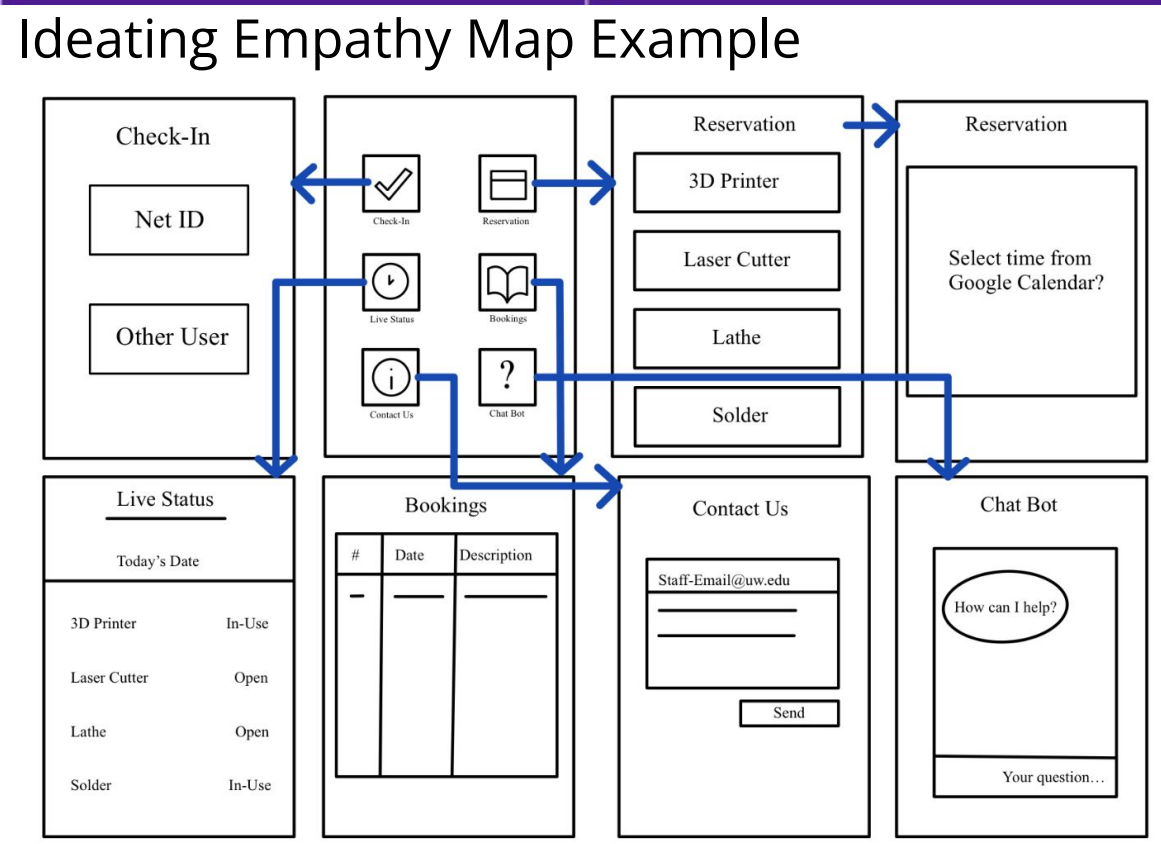
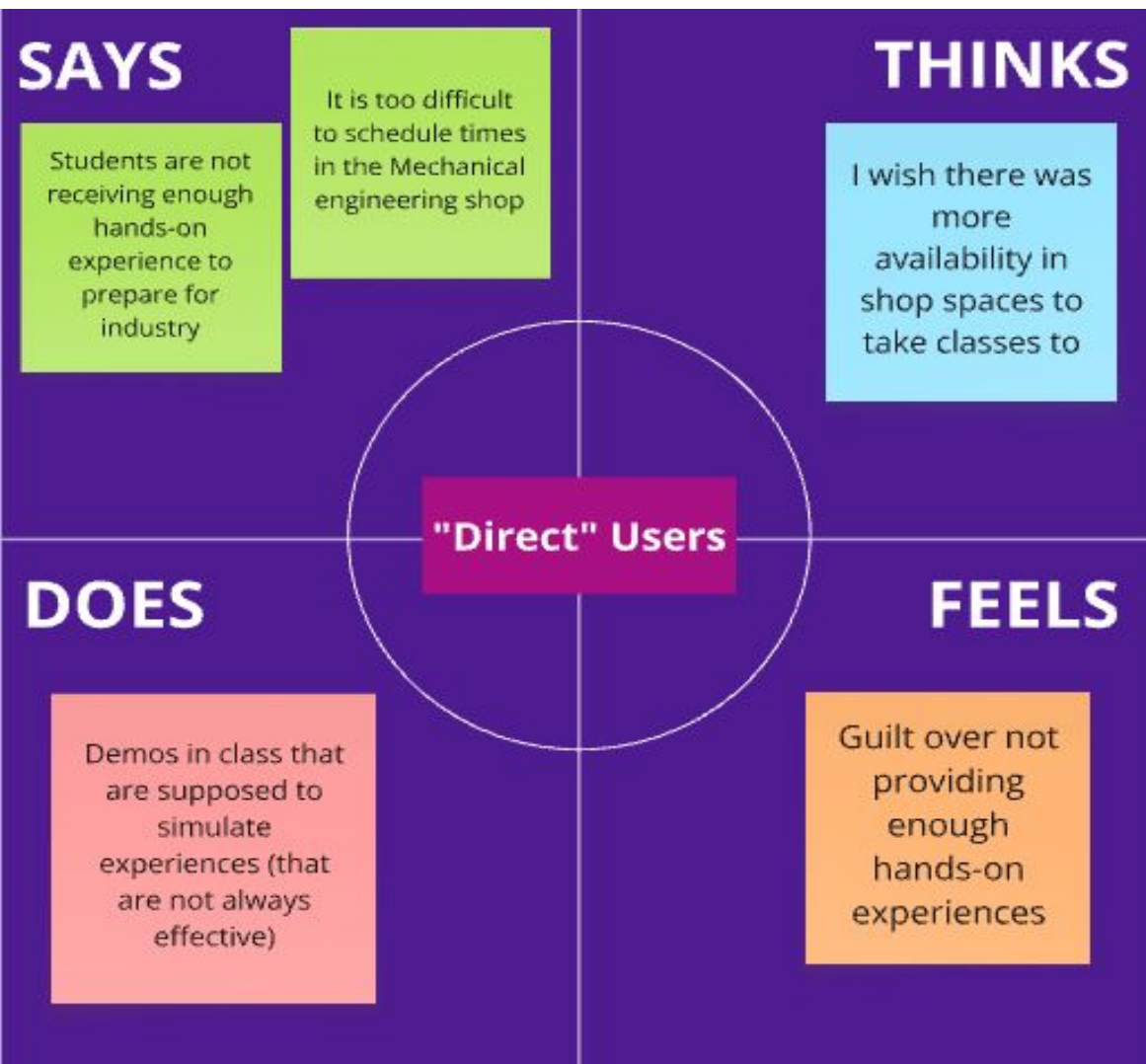
- Scheduling app model in Figma
- Developed that model into a website format
- Evaluated using usability heuristics.

Testing

- User-testing with our team to identify areas of confusion
- Iterated design based off feedback

Observing

- Identified areas of confusion and misclicks for revisions
- Further iterations



Key Attributes

Hybrid First-Come, First-Served and Scheduled model

Focus Scheduling on Smaller machines

Live status view

QR-code check in system

Online bookings for trainings

AI Chatbot Integration

Benefits

- Saves check-in and waiting time
- Increases visibility of system status
- Creates further app development opportunity as space develops



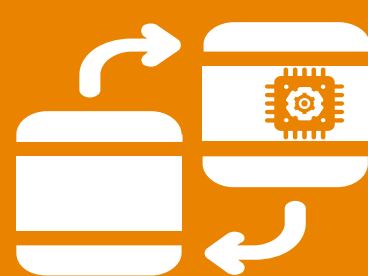
Website QR



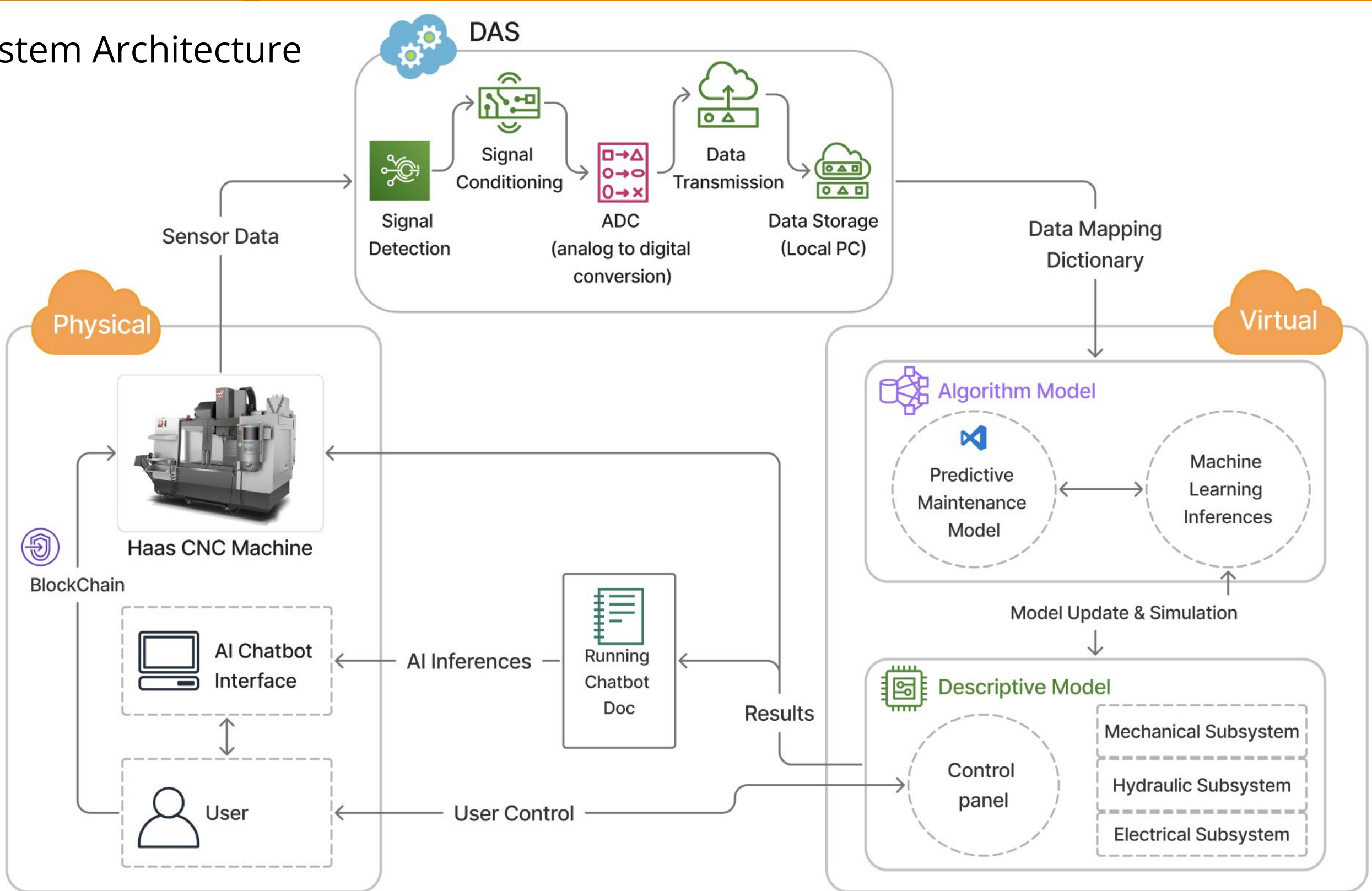
Figma QR

Augmentation 2

Predictive Maintenance-Centered Digital Twin for CNC Machines



DT System Architecture



Sensor	Signal	Annual cost
Dynamometer	Cutting Force	~\$2,000
Accelerometer	Vibration	~\$400
Software Type	Name	Annual Cost
CAM	MasterCam	Free
CAD	AutoCad	Free
UML	Simulink	~\$5,000
CAE	VERICUT	~\$20,000
Twin Builder	ANSYS	~\$2,000/

A **Digital Twin** (DT) is a virtual representation of a physical object featuring a bi-directional data stream of real-time sensor and results data.

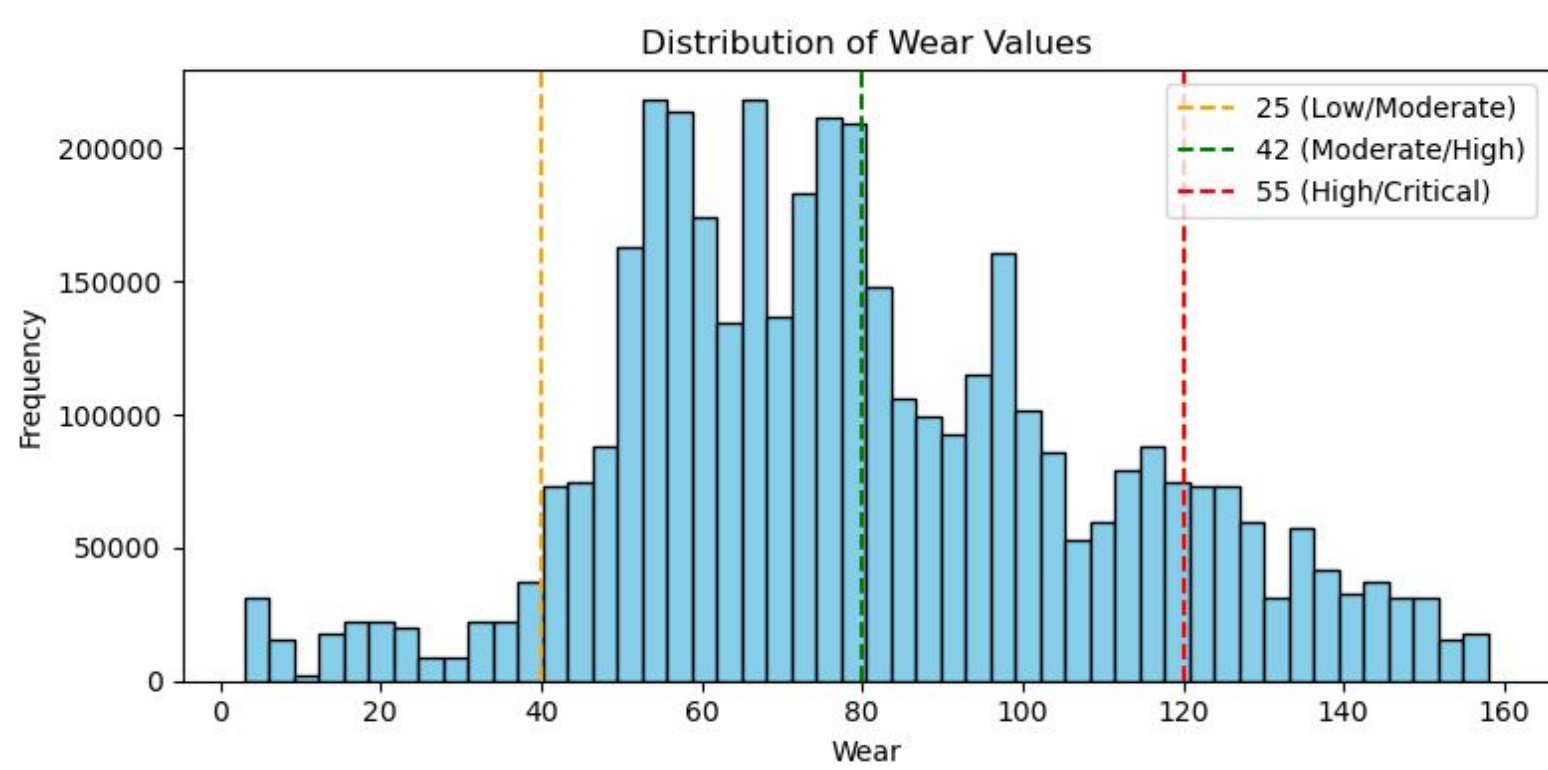
Benefits

- Data-driven optimization
- Reduce unscheduled downtime
- Cost efficiency
- Eliminate material waste
- Scalability and reusability

Predictive Maintenance

ANN & LSTM

Gradient Boosting



Predictive Maintenance (PdM) in a Digital Twin allows users to change parameters and simulate effects on tool wear virtually, reducing time and material waste.

*Open Source Dataset, 4M+ Data Points

ANN & LSTM Model

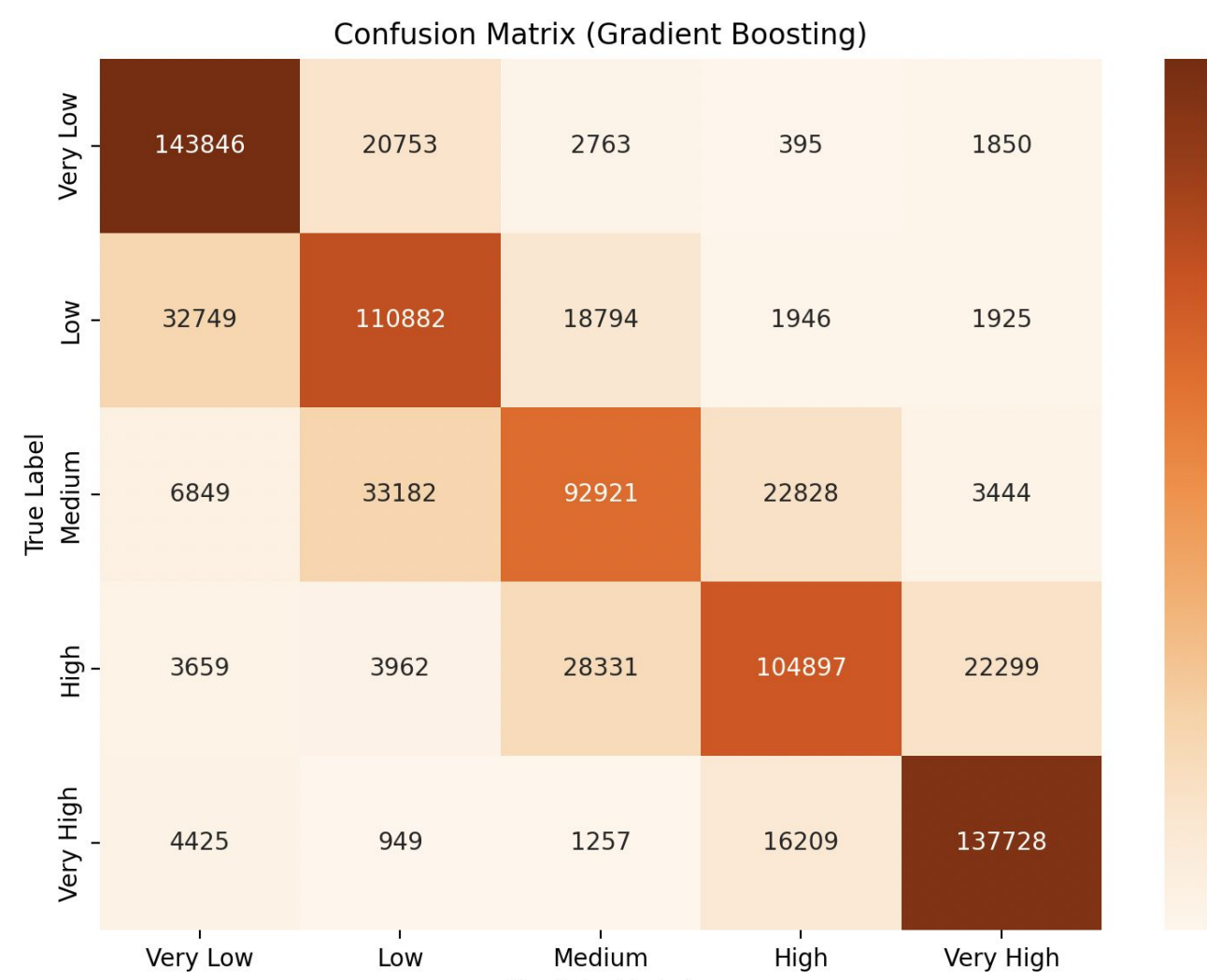
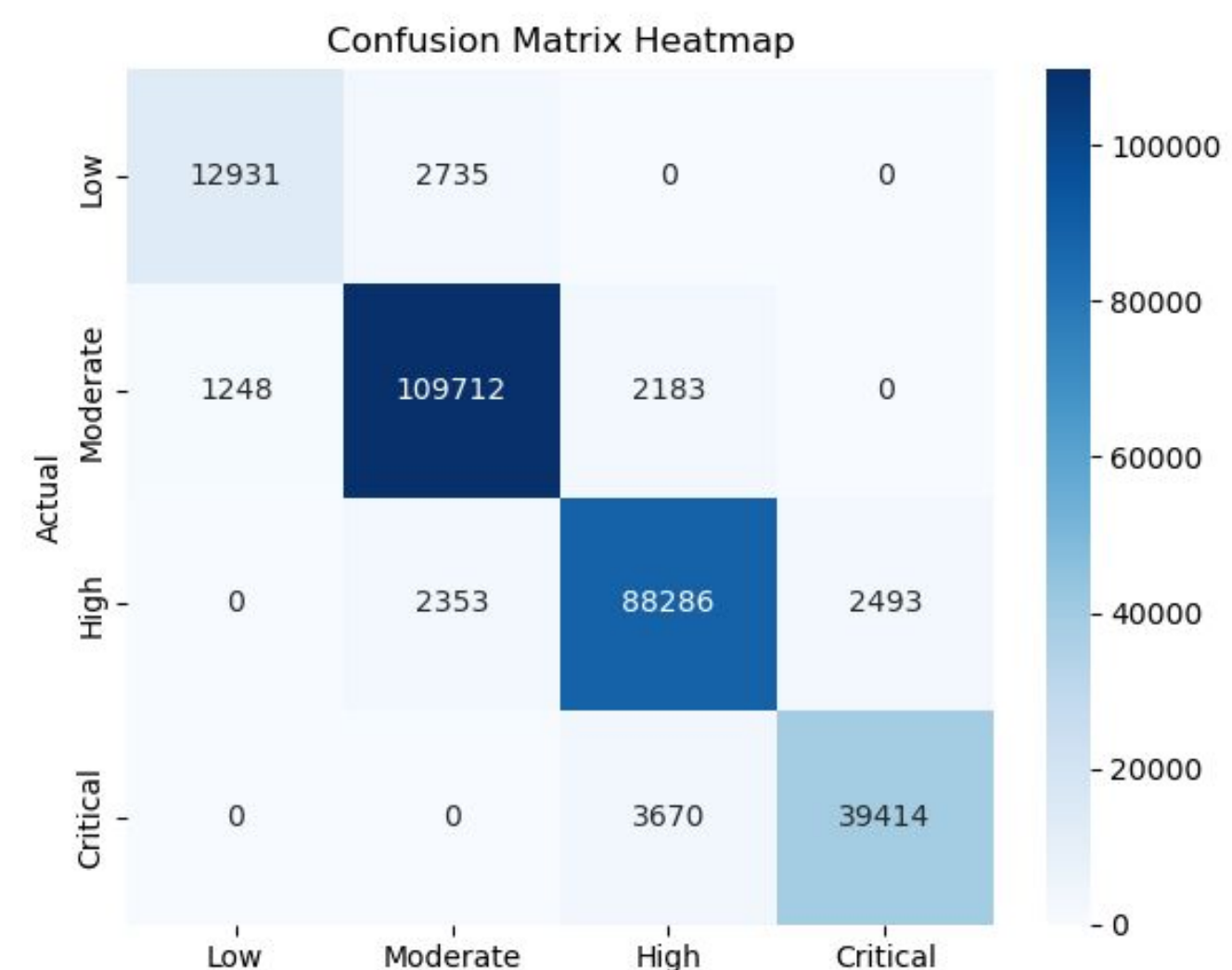
Accuracy: **94%**

ANN: Artificial Neural Networks

Ideal for learning complex behaviours to predict RUL (Remaining Useful Life)

LSTM: Long Short-Term Memory

Adds retention of sequence history for time-series data



Gradient Boosting Model

Accuracy: **72%**

- Training: 80%
- Predicting & testing: 20%

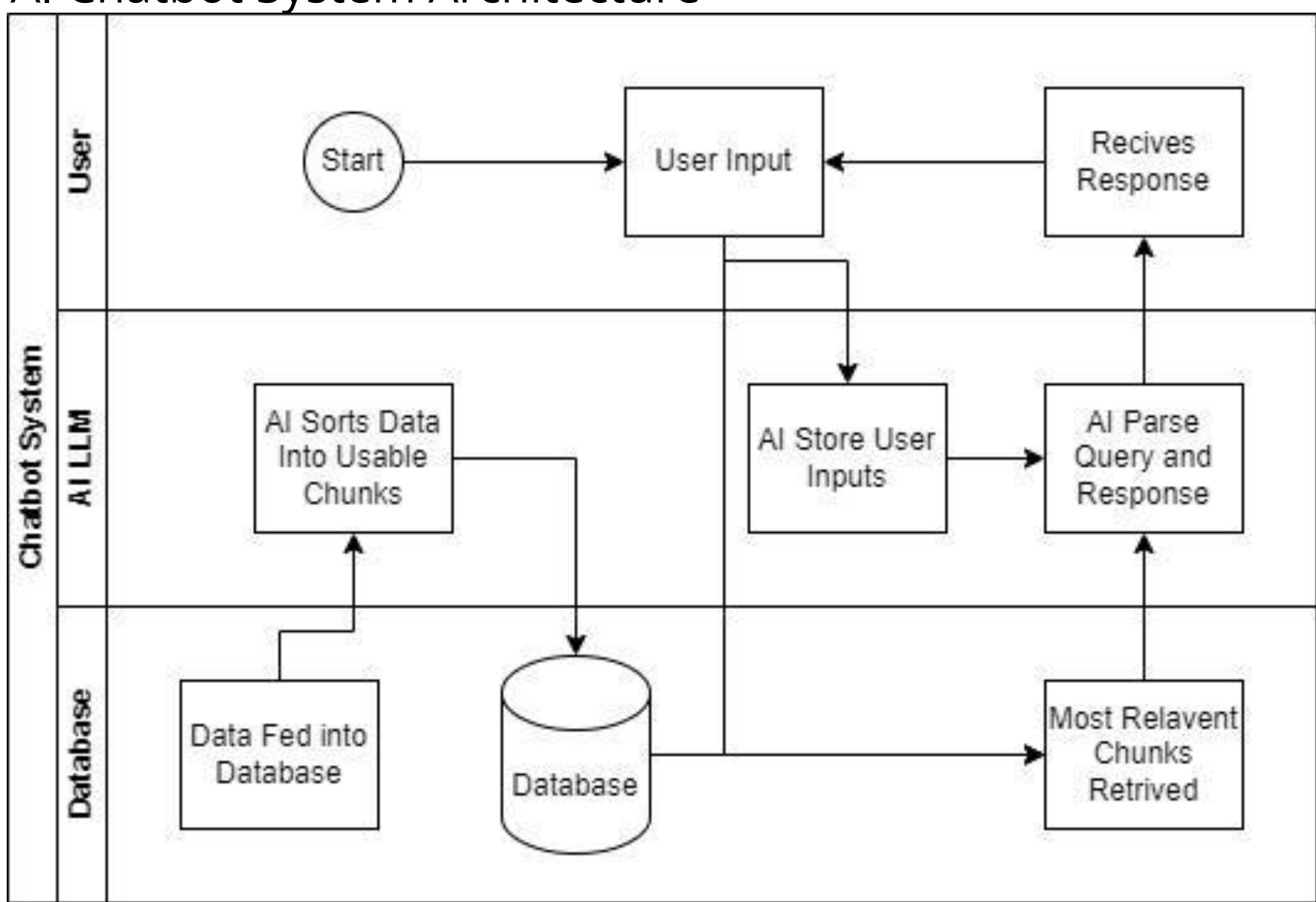
Good to capture non-linear patterns
Decent performance predicting extreme scenarios

Augmentation 3

AI Chatbot



AI Chatbot System Architecture



Benefits

- 24/7 access worldwide
- Saves time for staff
- Interconnectivity and growth
- Handles small questions
- Cheap and easy to modify

Chatbot QR



Purpose

The AI Chatbot is a conversational interface meant to assist users with simple questions about the space.

- Acclimates students to the space
- Introduce users to machines
- Provide general instructions
- Inform students of space rules and policies
- Provide contact information
- Can interconnect systems in shop

Combined Benefits

$$120_{\text{Hrs}} + 240_{\text{Hrs}} + 192_{\text{Hrs}} = 552_{\text{Hrs/Yr}}$$

Scheduling

Digital Twin

AI Chatbot

Saved by users

Future Recommendations

Scheduling

- Implement website prototype design to current IEB website
- Connect calendar system to website interface
- Create a check-in point to the lab to ensure safety and track usage

Digital Twin

- Integrate with cameras for up-to-date virtual modeling
- Evolve into HDTs (Human Digital Twins), modeling human interactions with machines
- Real-time data acquisition

AI Chatbot

- Implementable on web pages
- Update as the space changes with time
- Develop specific AI agents: Introductions Liaison, Lab Assistant, Scheduling Assistant, etc